

Appln No. 10/596,122
Amdt date September 16, 2011
Reply to Office action of March 16, 2011

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Currently Amended) A method executed by a processor for producing a combined adaptive directional signal, the method comprising:

deriving from one of two omni-directional microphones a first signal having an omni-directional polar pattern;

deriving from the two omni-directional microphones a second signal having a bi-directional polar pattern[[,]]; and

constructing the combined adaptive directional signal from a weighted sum of a first signal weight of the first signal and a second signal weight of the second signal,

wherein the first signal weight and the second signal weights are calculated in a non-iterative manner by ~~an optimiser, the optimiser~~ taking the first signal and the second signal as inputs, and ~~the optimiser~~ determining from the first and second signals the first and second signal weights by mathematically calculating the first and second signal weights in a manner to comply with predefined constraints that: (i) the weighted sum is to give the combined adaptive directional signal a constant gain in a predetermined direction, by imposing a constraint that the first signal weight and the second signal weight add to a predetermined value and (ii) power of the combined adaptive directional signal is substantially minimized by ensuring that the derivative with respect to signal weight of the energy of the output signal is ~~about zero, and~~ wherein the first signal weight and the second signal weight are calculated for a series of frames, each frame having a predetermined length including first signal samples and second signal samples, and wherein the first signal weight and the second signal weight are smoothed to minimise frame-to-frame variation in the calculated weights.

2-3. (Canceled)

Appln No. 10/596,122
Amdt date September 16, 2011
Reply to Office action of March 16, 2011

4. (Currently Amended) A method according to claim 1 executed by a processor for producing a combined adaptive directional signal, the method comprising:

deriving from one of two omni-directional microphones a first signal having an omni-directional polar pattern;

deriving from the two omni-directional microphones a second signal having a bi-directional polar pattern; and

constructing the combined adaptive directional signal from a weighted sum of a first signal weight of the first signal and a second signal weight of the second signal,

wherein the first signal weight and the second signal weights are calculated in a non-iterative manner by taking the first signal and the second signal as inputs, and determining from the first and second signals the first and second signal weights by mathematically calculating the first and second signal weights in a manner to comply with predefined constraints that: (i) the weighted sum is to give the combined adaptive directional signal a constant gain in a predetermined direction, by imposing a constraint that the first signal weight and the second signal weight add to a predetermined value and (ii) power of the combined adaptive directional signal is substantially minimized by ensuring that the derivative with respect to signal weight of the energy of the output signal is zero, and

wherein the signal weights are calculated by solving the following equation:

$$a = \frac{\sum y^2 - \sum xy}{\sum x^2 - 2\sum xy + \sum y^2}$$

Where:

a = weight for the first signal

$(1-a)$ = weight for the second signal

x = first signal sample

y = second signal sample.

5. Cancelled.

Appln No. 10/596,122
Amdt date September 16, 2011
Reply to Office action of March 16, 2011

6. (Currently Amended) A method according to claim [[5]] 1, wherein N=64 the predetermined length of each frame includes 64 first signal samples and 64 second signal samples.

7. Cancelled.

8. (Currently Amended) A method according to claim 4[[1]], wherein the first and second signals are sampled, the signal weights being calculated for successive sets of said first and second signals samples.

9. (Previously presented) A method according to claim 4, wherein the first and second signals are sampled, the signal weights being calculated for successive sets of said first and second signals samples, and the signal weights are calculated continuously by calculating x^2 , y^2 , and xy for each sample and adding them to an appropriate running sum.

10. (Currently Amended) A method according to claim 9, wherein a leaky integrator is used to perform the running sum in order to address issues of numerical overflow.

11. (Currently Amended) A method in accordance with claim 1, wherein whereby said signal weights are calculated so as to construct an omni-directional combined signal when a total power in said first signal is below a certain value.

12. (Currently Amended) A method according to claim 4, wherein whereby said signal weights are calculated so as to construct an omni-directional combined signal when a total power in said first signal is below a certain value and value α defaults to a value of 1.0 in the event that Σx^2 is less than a prescribed minimum value.

Appln No. 10/596,122
Amdt date September 16, 2011
Reply to Office action of March 16, 2011

13. (Previously presented) A method according to claim 1, wherein the omni-directional microphones comprise a front microphone and a rear microphone, and said predetermined direction is the forward direction along the microphone axis.
14. (Original) A method according to claim 13, wherein the second signal is provided by the difference between signals produced by the front and rear microphones, without the use of a delay element.
15. (Previously presented) A method according to claim 14, further comprising processing the second signal by means of an integrator element or an integrator-like filter before constructing the combined signal, thereby compensating for the attenuation of low frequencies and phase shifts introduced in the subtraction of the two omni-directional signals.
16. (Previously presented) A method according to claim 14, further comprising amplifying the signals produced by the front and/or the rear microphone before constructing the bi-directional signal, to ensure an equivalent gain between the microphones.
17. (Previously presented) A method according to claim 1, wherein said first and second signals are frequency domain samples.
18. (Previously presented) A method according to claim 17, further comprising calculating and applying the weights to several independent subsets of frequency domain samples, to give different directional responses at different frequencies and/or to allow selective suppression of different frequencies.
19. (Previously presented) A method according to claim 1, comprising applying a frequency weighting function to said first and second signal before calculating said signal weights.

Appln No. 10/596,122
Amdt date September 16, 2011
Reply to Office action of March 16, 2011

20. (Currently Amended) An apparatus for producing a combined adaptive directional signal, the apparatus comprising:

an analog-to-digital converter for producing from one of two omni-directional microphones a first signal having an omni-directional polar pattern; and

a differencing element for deriving from the two omni-directional microphones a second signal having a bi-directional polar pattern;

a summation device for constructing the adaptive directional signal from a weighted sum of a first signal weight of the first signal and a second signal weight of the second signal; and

an optimiser for calculating the first signal weight and the second signal weight in a non-iterative manner, the optimiser taking the first signal and the second signal as inputs, and the optimiser determining from the first and second signals the first and second signal weights by mathematically calculating the first and second signal weights in a manner to comply with predefined constraints that: (i) the weighted sum is to give the combined adaptive directional signal a constant gain in a predetermined direction, by imposing a constraint that the first signal weight and the second signal weight add to a predetermined value and (ii) power of the combined adaptive directional signal is substantially minimized by ensuring that the derivative with respect to signal weight of the energy of the output signal is about zero, wherein the first signal weight and the second signal weight are calculated for a series of frames, each frame having a predetermined length including first signal samples and second signal samples; and

a filter for filtering or smoothing the first signal weight and the second signal weight to minimise frame-to-frame variation in the calculated weights.

21. (Canceled)

22. (Currently Amended) An apparatus according to claim 20, including means for calculating for producing a combined adaptive directional signal, the apparatus comprising:

an analog-to-digital converter for producing from one of two omni-directional microphones a first signal having an omni-directional polar pattern;

Appln No. 10/596,122
Amdt date September 16, 2011
Reply to Office action of March 16, 2011

a differencing element for deriving from the two omni-directional microphones a second signal having a bi-directional polar pattern;

a summation device for constructing the adaptive directional signal from a weighted sum of a first signal weight of the first signal and a second signal weight of the second signal; and

an optimiser for calculating the first signal weight and the second signal weight in a non-iterative manner, the optimiser taking the first signal and the second signal as inputs, and the optimiser determining from the first and second signals the first and second signal weights by mathematically calculating the first and second signal weights in a manner to comply with predefined constraints that: (i) the weighted sum is to give the combined adaptive directional signal a constant gain in a predetermined direction, by imposing a constraint that the first signal weight and the second signal weight add to a predetermined value, and (ii) power of the combined adaptive directional signal is substantially minimized by ensuring that the derivative with respect to signal weight of the energy of the output signal is zero, wherein

the optimiser is configured to calculate the weights by solving the following equation:

$$a = \frac{\sum y^2 - \sum xy}{\sum x^2 - 2\sum xy + \sum y^2}$$

Where:

a = weight for the first signal

$(1-a)$ = weight for the second signal

x = first signal sample

y = second signal sample.

23. (Currently Amended) An apparatus according to claim 22 [[20]], including means for calculating said signal weights for a series of frames, each frame having a predetermined length consisting of N first signal samples and N second signal samples.

Appln No. 10/596,122
Amdt date September 16, 2011
Reply to Office action of March 16, 2011

24. (Currently Amended) An apparatus according to claim 22 [[20]], including a filter for filtering or smoothing the series of weights to minimize frame-to-frame variation in the calculated weights.
25. (Currently Amended) An apparatus according to claim 22 [[20]], including means for calculating said weights continuously for samples of said first and second signals.
26. (Previously presented) An apparatus according to claim 20, including a leaky integrator to perform a running sum on said first and second signal samples in order to address issues of numerical overflow system memory.
27. (Previously presented) An apparatus according to claim 20, including means for calculating said signal weights so as to construct an omni-directional combined signal when a total power in said first signal is below a certain value.
28. (Previously presented) An apparatus according to claim 20, wherein the two spaced omni-directional microphones comprise a front and a rear microphone, signals from which are used for deriving said first and second signals, and said predetermined direction is the forward direction along the microphone axis.
29. (Original) An apparatus according to claim 28, including means for providing said second signal from the difference between signals produced by the front and rear microphones, without the use of a delay element.
30. (Previously presented) An apparatus according to claim 28, including an integrator element or an integrator-like filter for processing the second signal before constructing the combined signal, thereby compensating for attenuation of low frequencies and phase shifts introduced in the provision of the second signal.

31. (Previously presented) An apparatus according to claim 28, including a means for amplifying the signals produced by the front and/or the rear microphone before the step of constructing the bi-directional signal, to ensure an equivalent gain between the microphones.

32. (Currently Amended) A computer program stored in a computer-readable storage medium, said computer program, when executed by a computer, performing the steps of:

deriving from one of two omni-directional microphones a first signal having an omni-directional polar pattern;

deriving from the two omni-directional microphones a second signal having a bi-directional polar pattern; and

constructing the combined adaptive directional signal from a weighted sum of a first signal weight of the first signal and a second signal weight of the second signal;

wherein the first signal weight and the second signal weights are calculated in a non-iterative manner by ~~an optimiser~~, the ~~optimiser~~ taking the first signal and the second signal as inputs, and ~~the optimiser~~ determining from the first and second signals the first and second signal weights by mathematically calculating the first and second signal weights in a manner to comply with predetermined constraints that: (i) the weighted sum is to give the combined adaptive directional signal a constant gain in a predetermined direction, by imposing a constraint that the first signal weight and the second signal weight add to a predetermined value and (ii) power of the combined adaptive directional signal is substantially minimized by ensuring that the derivative with respect to signal weight of the energy of the output signal is about zero, and wherein the first signal weight and the second signal weight are calculated for a series of frames, each frame having a predetermined length including first signal samples and second signal samples, and wherein the first signal weight and the second signal weight are smoothed to minimise frame-to-frame variation in the calculated weights.

Appln No. 10/596,122
Amdt date September 16, 2011
Reply to Office action of March 16, 2011

33. (New) A method according to claim 1, wherein the first signal weight and the second signal weights are calculated in time domain.

34. (New) A method according to claim 1, wherein said one of two omni-directional microphones is a front microphone and the other one of omni-directional microphone is a rear microphone, and wherein the front and rear microphones are matched.